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# Bell-CHSH violation under global unitary operations: Necessary and sufficient conditions

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## Abstract

The relation between Bell-CHSH violation and factorization of Hilbert space is considered here. That is, a state which is local in the sense of the Bell-CHSH inequality under a certain factorization of the underlying Hilbert space can be Bell-CHSH nonlocal under a different factorization. While this question has been addressed with respect to separability, the relation of the factorization with Bell-CHSH violation has remained hitherto unexplored. We find here that there is a set containing density matrices, which do not exhibit Bell-CHSH violation under any factorization of the Hilbert space brought about by global unitary operations. Using the Cartan decomposition of  $SU(4)$ , we characterize the set in terms of a necessary and sufficient criterion based on the spectrum of density matrices. Sufficient conditions are obtained to characterize such density matrices based on their Bloch representations. For some classes of density matrices, necessary and sufficient conditions are derived in terms of Bloch parameters. Furthermore, an estimation of the volume of such density matrices is achieved in terms of purity. The criterion is applied to some well-known class of states in two qubits. Since both local filtering and global unitary operations influence the Bell-CHSH violation of a state, a comparative study is made between the two operations. The inequivalence of the two operations (in terms of increasing Bell-CHSH violation) is exemplified through their action on some classes of states.

**Keywords:** Bell-CHSH - global unitary operation

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